Evaluation of Rainfall-Runoff Trends in the Upper Colorado River Basin Phase II

Project Update for BBASC

July 10, 2019

Project Funded Through TWDB Contract Number 1800012283

TWDB HAS NOT (yet) APPROVED DRAFT RESULTS PRESENTED HEREIN

Study Phase-1: Objectives and Results

Objectives

1. Are recent observed flows in the Colorado River basin upstream of the Highland Lakes substantially lower than historical flows?
2. If so, what are the likely reasons for the disparity?

Results

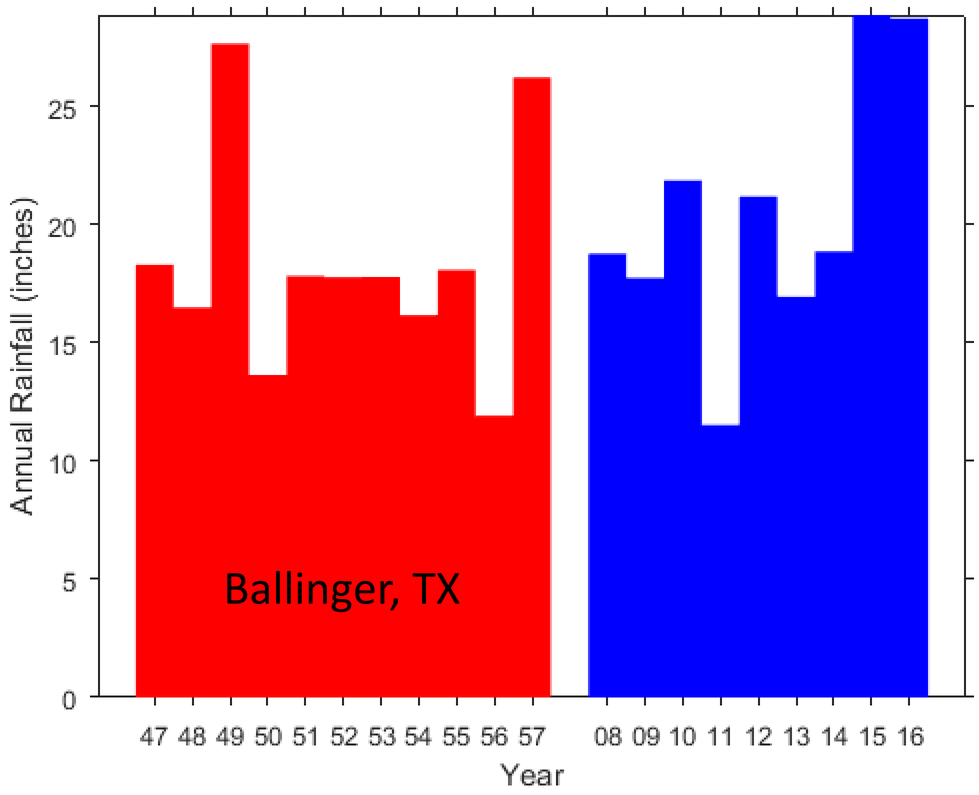
1. Observed flows declined at all study sites over the period 1940–2016.
2. Decline in a majority of the sites can be attributed to historical water use and the construction of large reservoirs upstream (all permitted).
3. For several of the study sites, declines in flow were not the result of permitted upstream withdrawals.
4. All sites showed some decline in naturalized flow over the period of record.
5. Such a decline indicates that activities not accounted for in the flow naturalization process may have impacted observed flows.

   - e.g. construction of small reservoirs, groundwater use, changes in average temperature, etc.

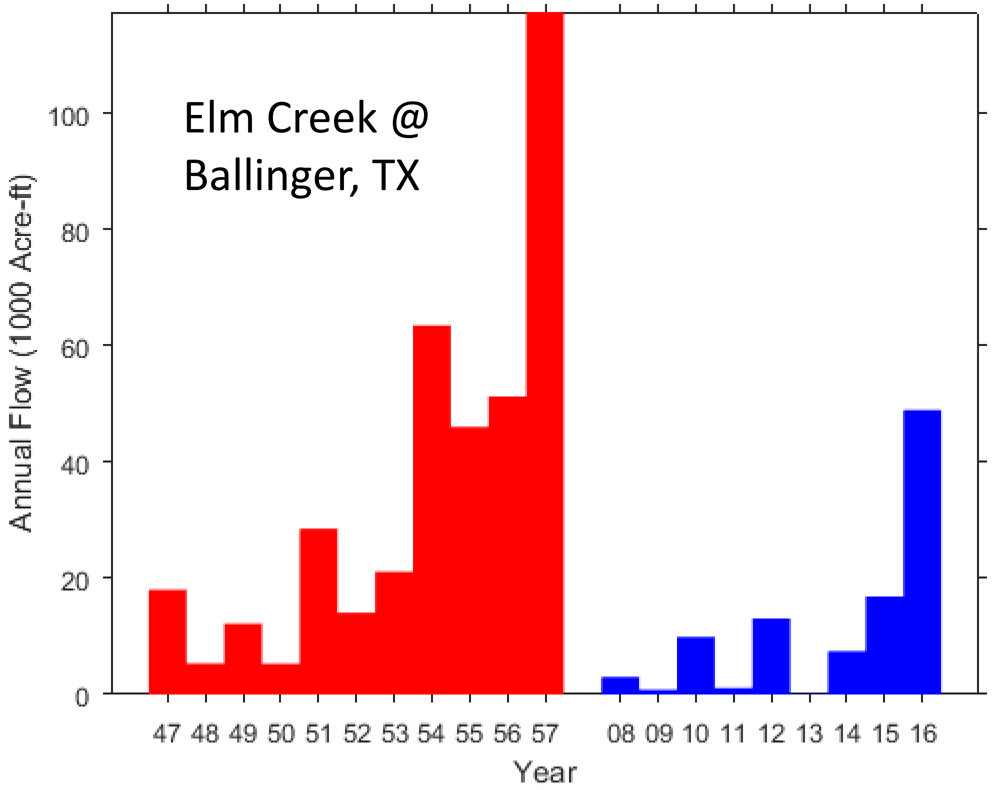
Graphical Summary of Phase 1 Results

"Rainfall in the 1950's was similar to that in the recent drought – yet recent streamflow was much lower"

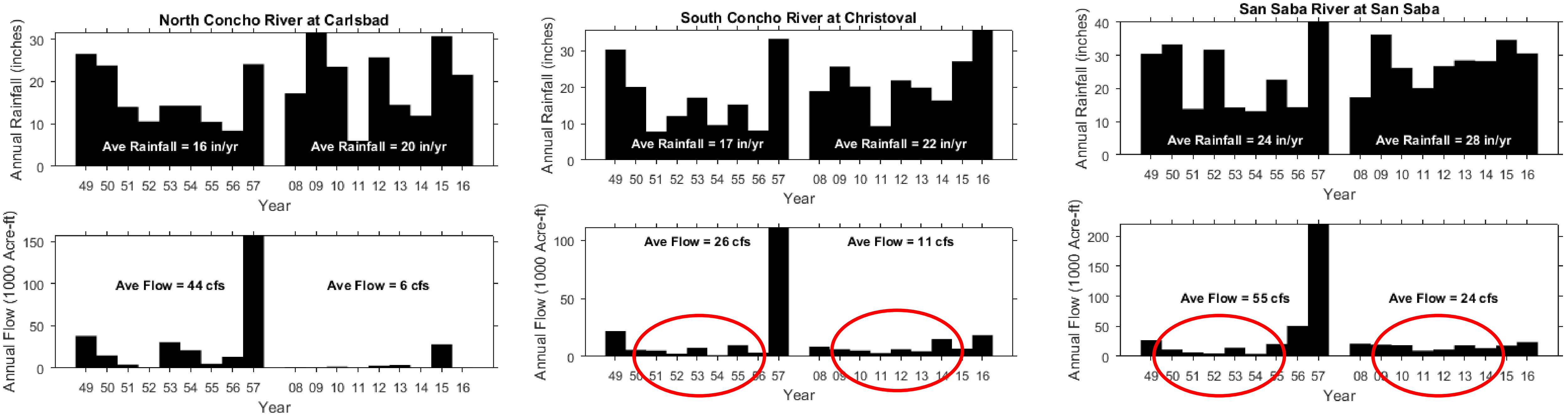
RAINFALL (inches)



Streamflow (1000 acre-ft)



Graphical Summary of Phase 1 Results – True for all of Study Area



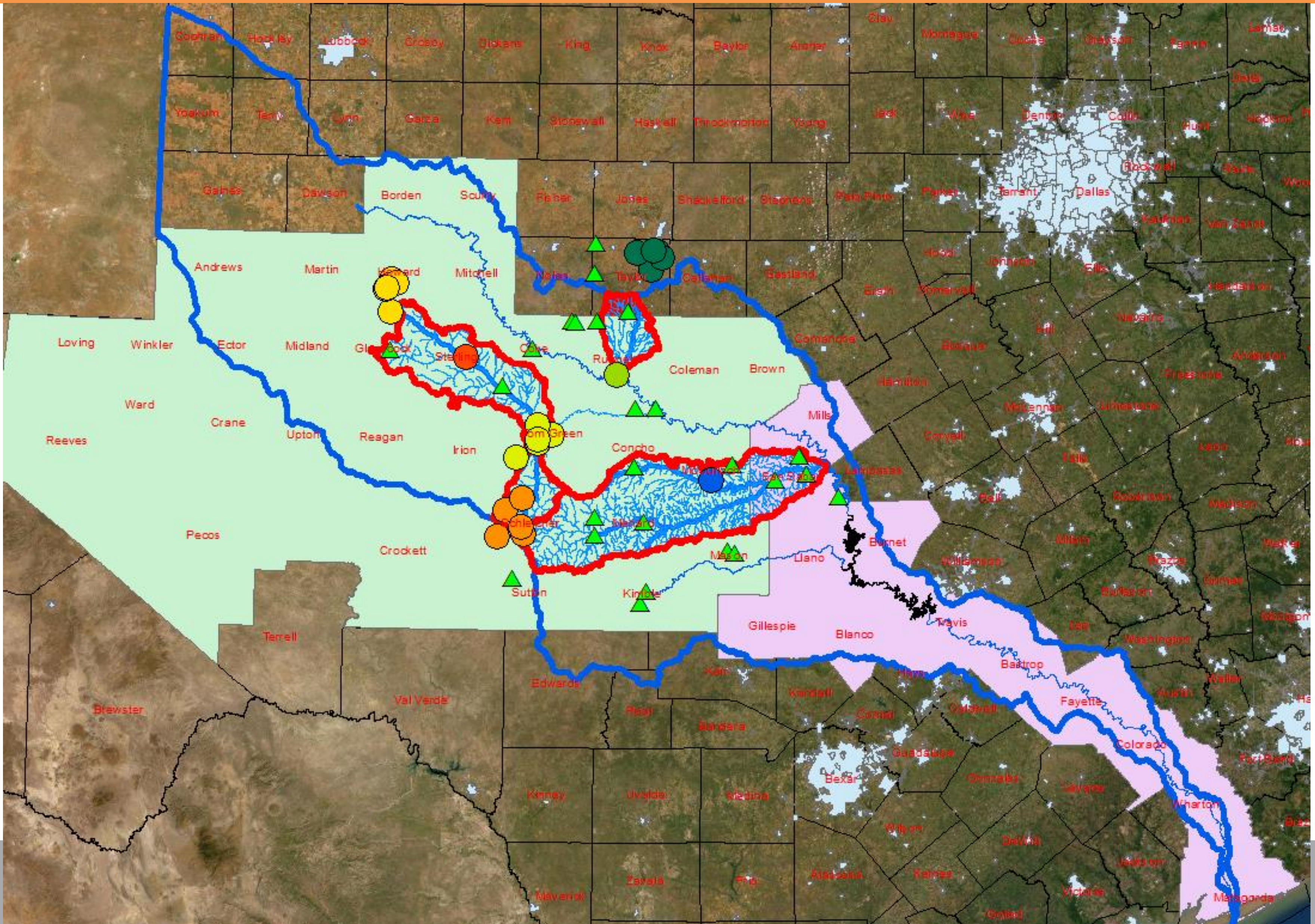
Study Phase-1: Recommendation

Recommendation:

1. Undertake a further study of potential factors affecting rainfall-runoff relationships within key sub-watersheds (North Concho at Carlsbad, Elm Creek near Ballinger, South Concho, and San Saba River watersheds).
2. Derive definitive conclusions for the attribution of observed rainfall-runoff relationships.

Link to Phase-1 report:
http://www.twdb.texas.gov/publications/reports/contracted_reports/doc/1600012011_Kennedy.pdf

Project Study Area



Majority of study area in Region F

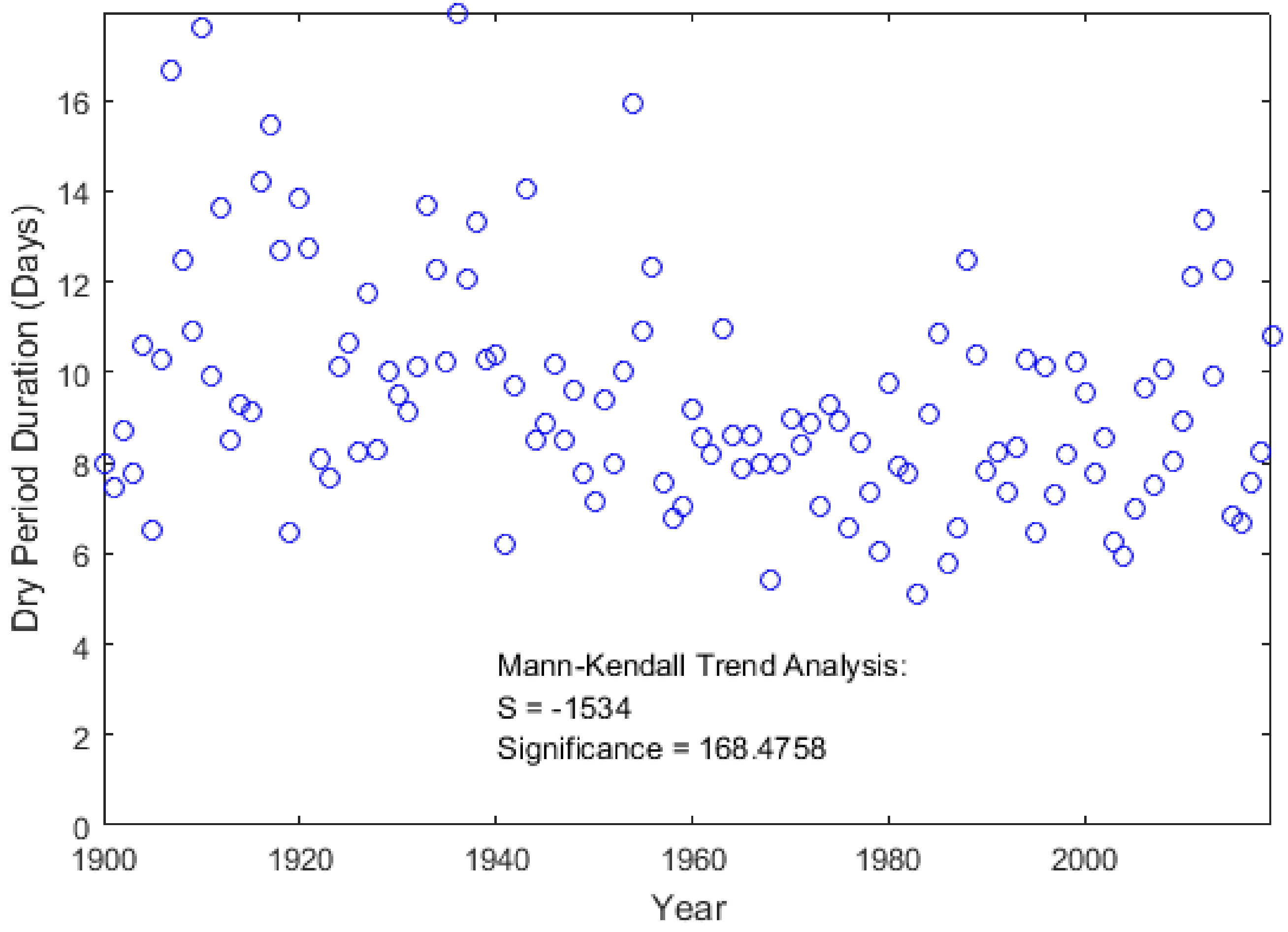
Results likely applicable to
Rest of Region F

Region G also interested:
Cedar Ridge Reservoir EIS

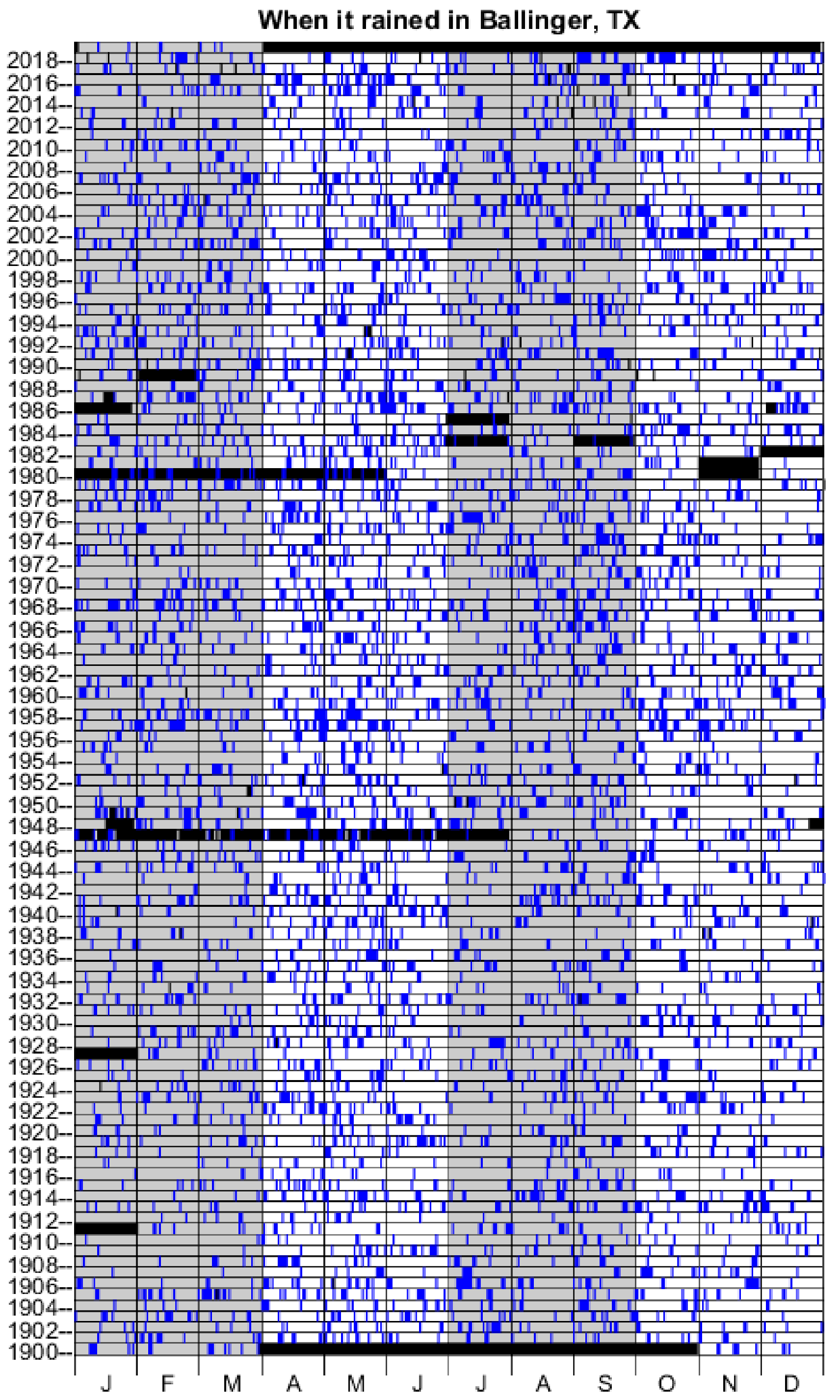
Region K has strong interest

LCRA has strong interest

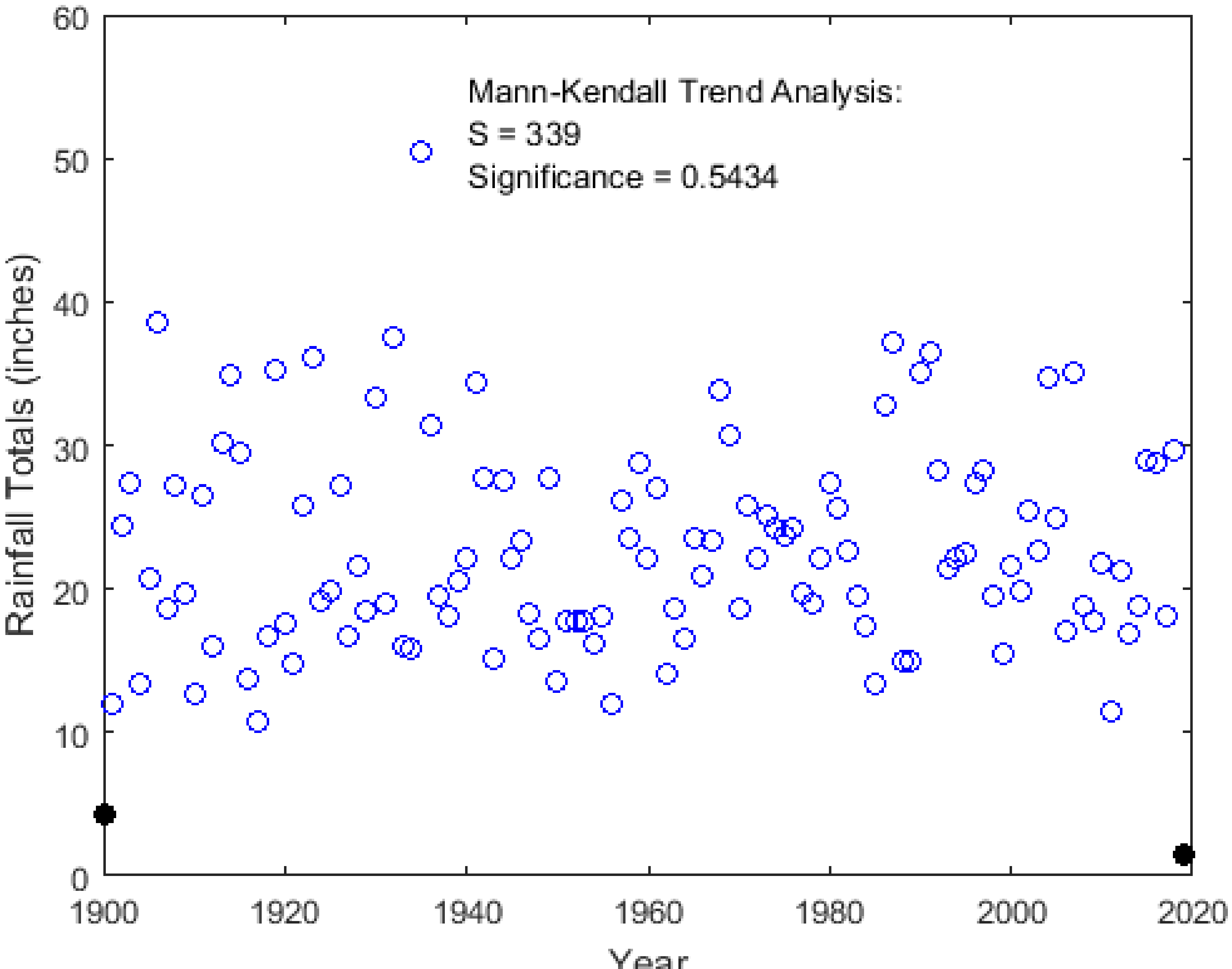
Precipitation Trend Analysis



Significant Decrease in length of dry periods

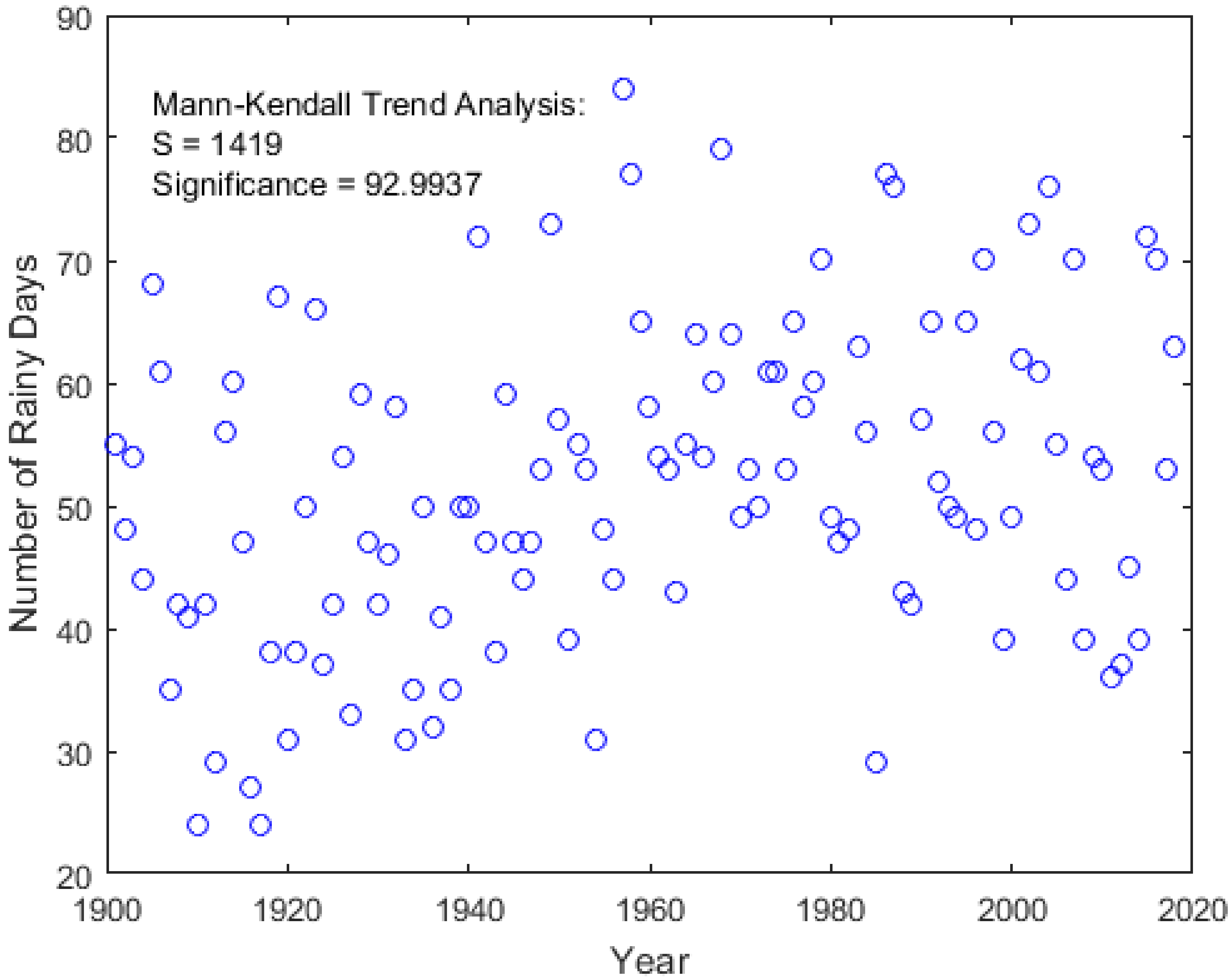


Task 5 – Precipitation Trend Analysis – Ballinger, TX



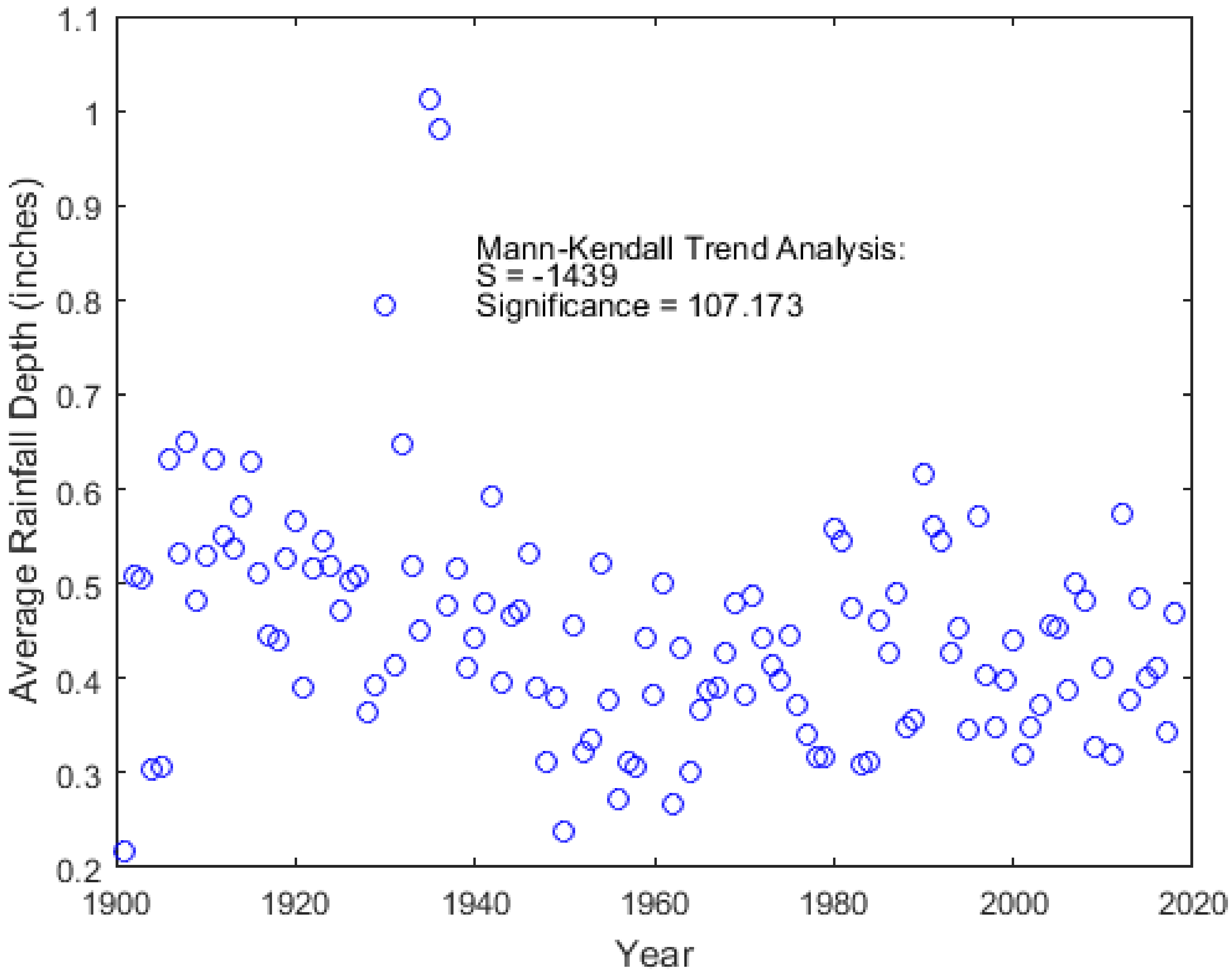
Ballinger TX – Total Annual Rainfall
No statistically Significant Trend

Task 5 – Precipitation Trend Analysis – Ballinger, TX



Ballinger, TX
Days of Recorded Rainfall
Significant Increasing Trend

Task 5 – Precipitation Trend Analysis – Ballinger, TX

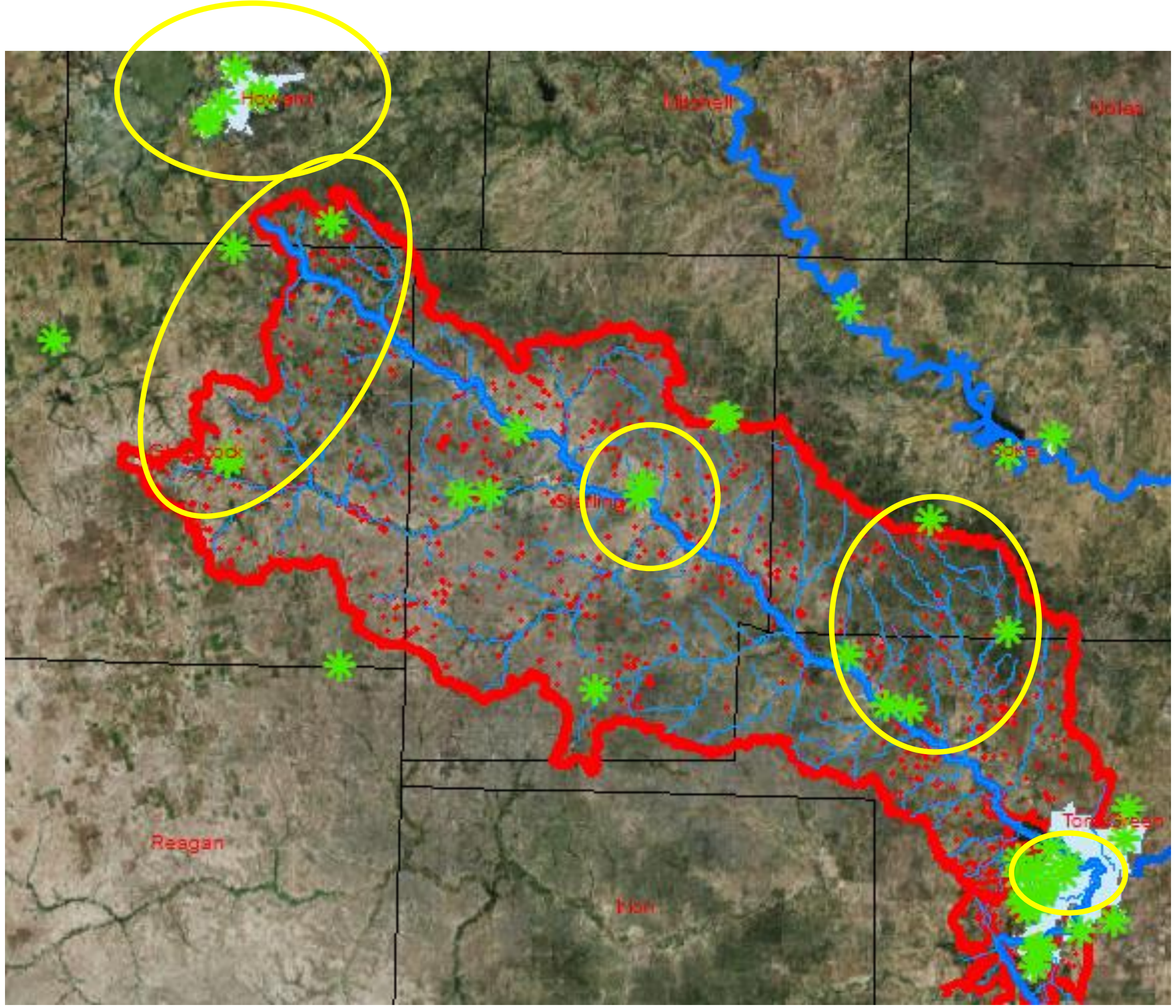


Ballinger, TX
Average Rainfall Depth
Significant Decreasing Trend

So.. Less rain more often…

Potentially less runoff as ground is not often Saturated.

Precipitation Trend throughout Study Area

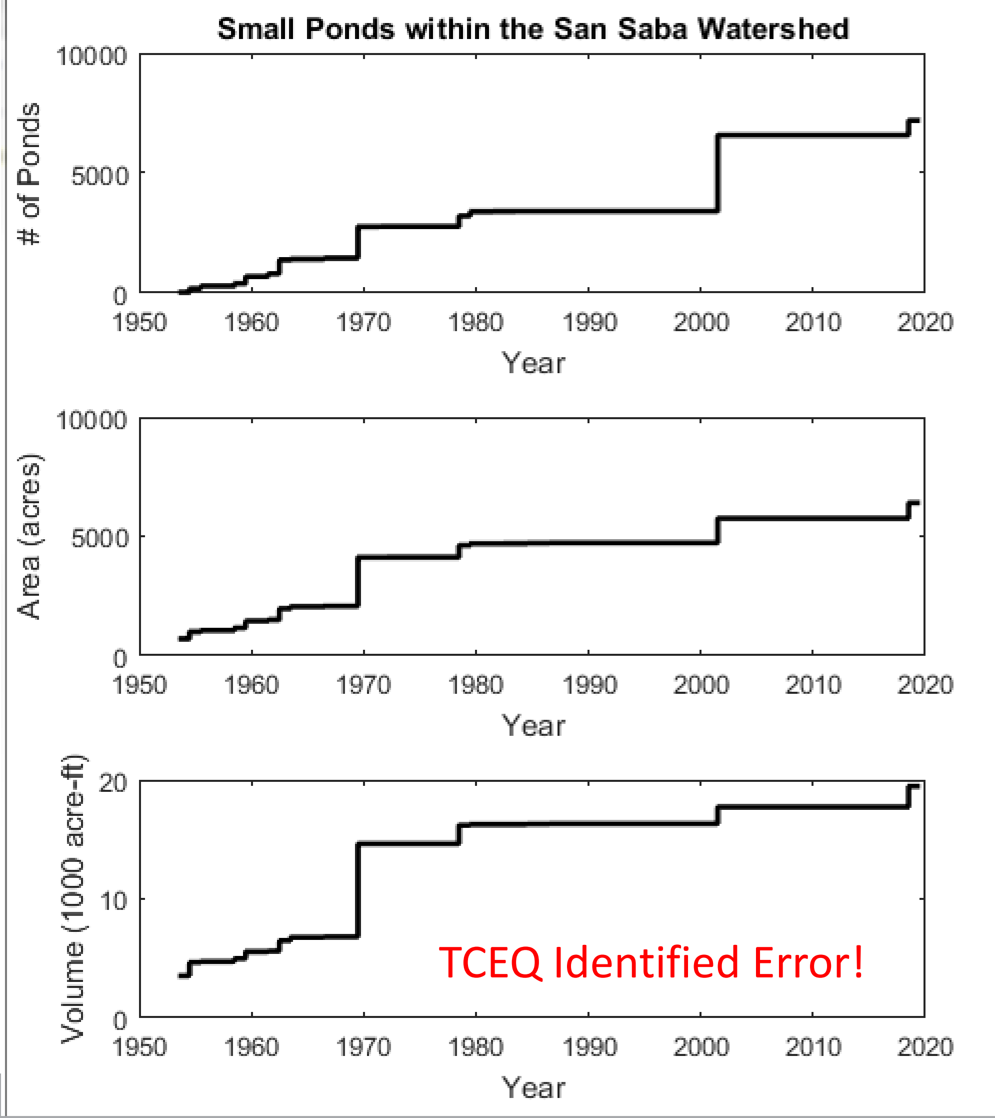


5 Rainfall Station Clusters in North Concho Watershed
All suggest static annual rainfall, more frequent, less-intense Rain events

Month	S	Significance
January	-64	0.41914
February	-89	0.43892
March	**399**	**2.8124**
April	-338	1.6382
May	-289	1.1084
June	58	0.41524
July	-164	0.5535
August	**385**	**2.4542**
September	41	0.4069
October	28	0.40256
November	21	0.40096
December	-9	0.39927

Rainfall Timing (in year) may be changing

Proliferation of Small Ponds in Watersheds



San Saba Watershed

Refining with Google Earth Engine: 1984-Present

Also Manual Review in Google Earth

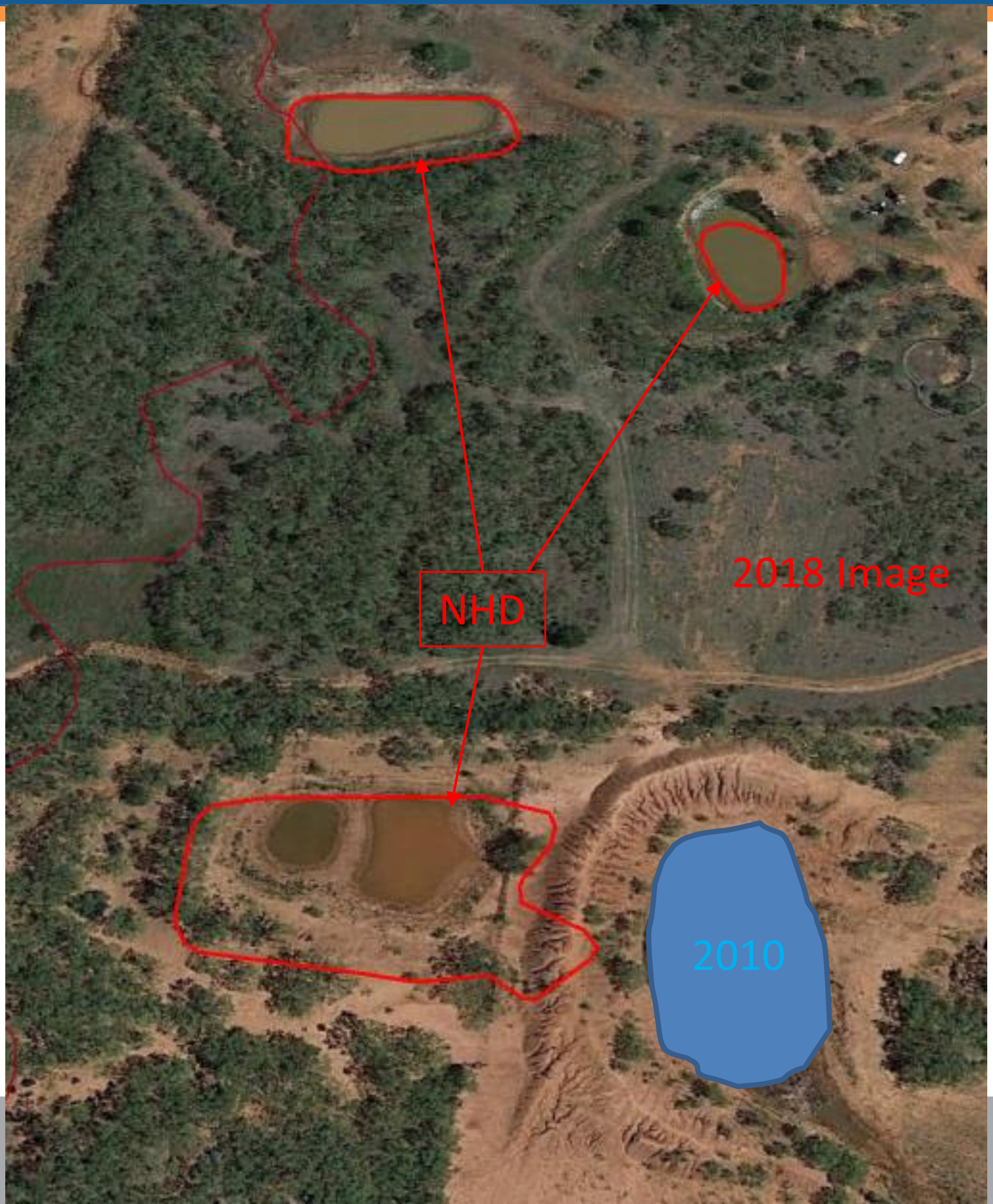
600 Additional Small Impoundments
Present in 2019 – Identified in Google Earth
Not Present in 2002 NHD

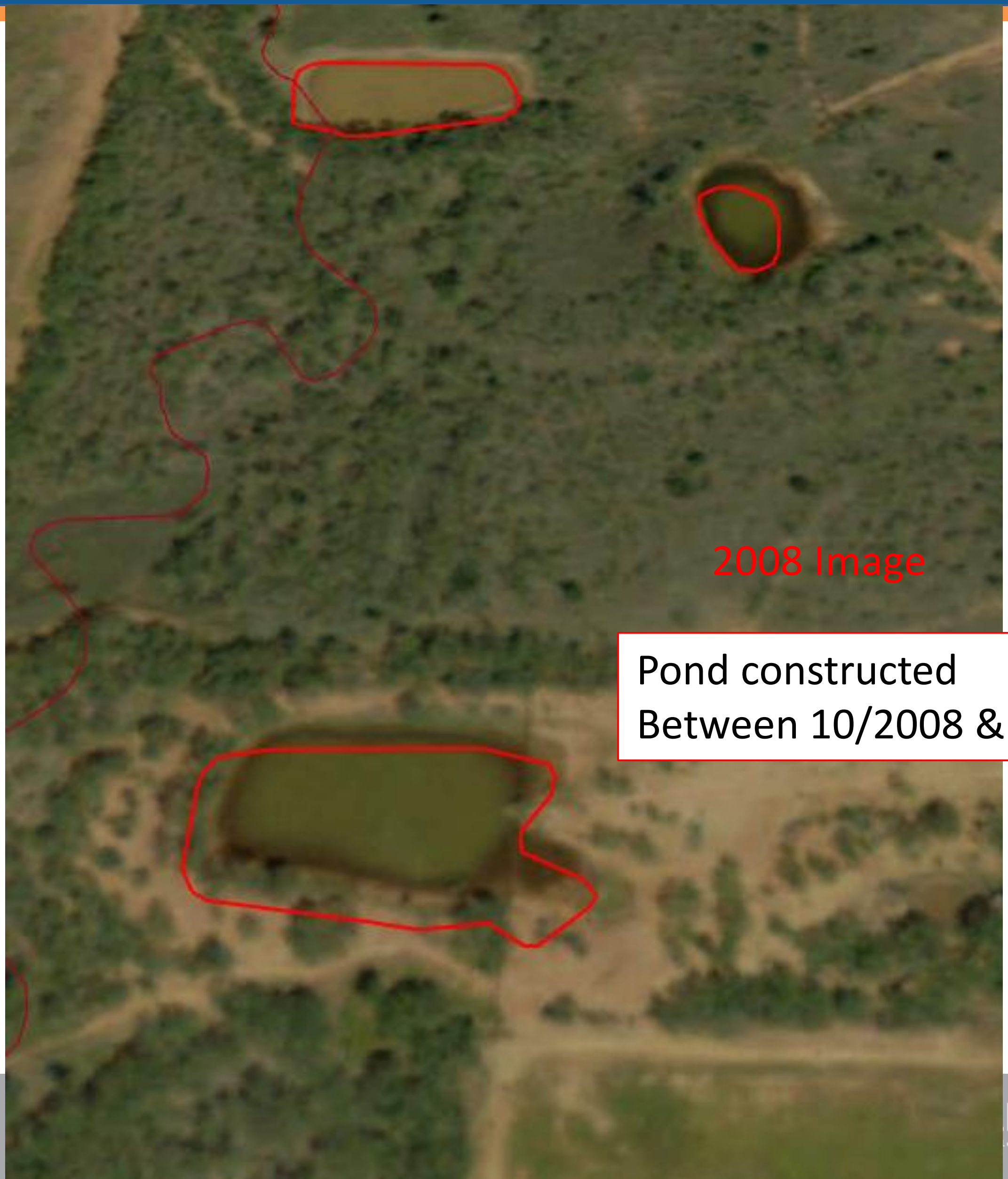
Small Impoundments:

- Water Loss to Evaporation
- Prevent runoff from reaching streams

**Volume estimated from WAM storage vs area relationship

Proliferation of Small Ponds in Watersheds





Pond constructed
Between 10/2008 & 3/2010

Temperature Trend Analysis

Ballinger Average Annual Minimum Temperature:
Significant Increasing Trend

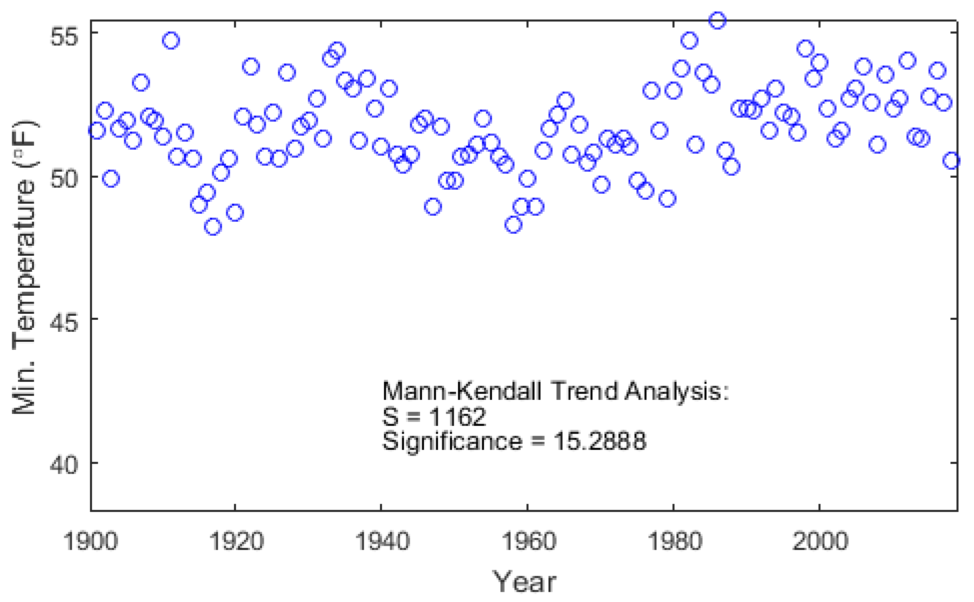
Ballinger Average Annual Maximum Temperature:
No Significant Trend

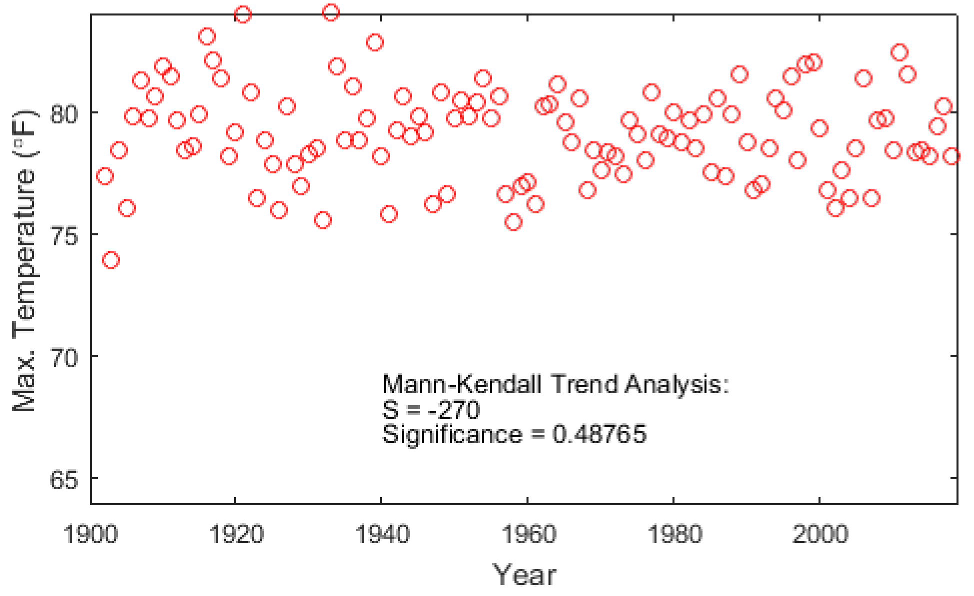
	Maximum		Minimum	
	S	Sig.	S	Sig.
Annual	-270	0.48	1162	15.28
Jan	322	0.52	-114	0.41
Feb	193	0.44	823	2.371
Mar	201	0.44	868	2.89
Apr	491	0.79	960	5.47
May	357	0.56	1687	872
Jun	-827	2.53	1107	10.92
Jul	-546	0.93	1366	80.41
Aug	-939	4.58	890	3.57
Sep	-716	1.59	595	1.04
Oct	193	0.44	660	1.29
Nov	328	0.54	656	1.31
Dec	609	1.08	83	0.41

Monthly Trends

Decreasing Summer Maximums

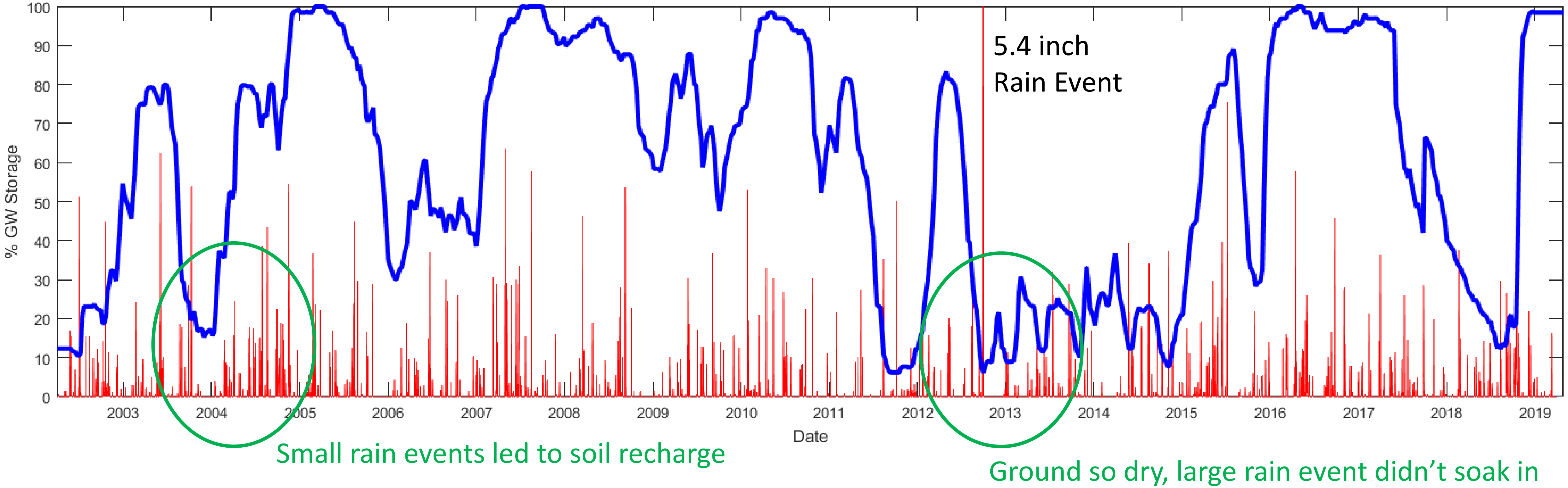
Increasing Minimums





Increase in Evapotranspiration == Decreased Streamflow

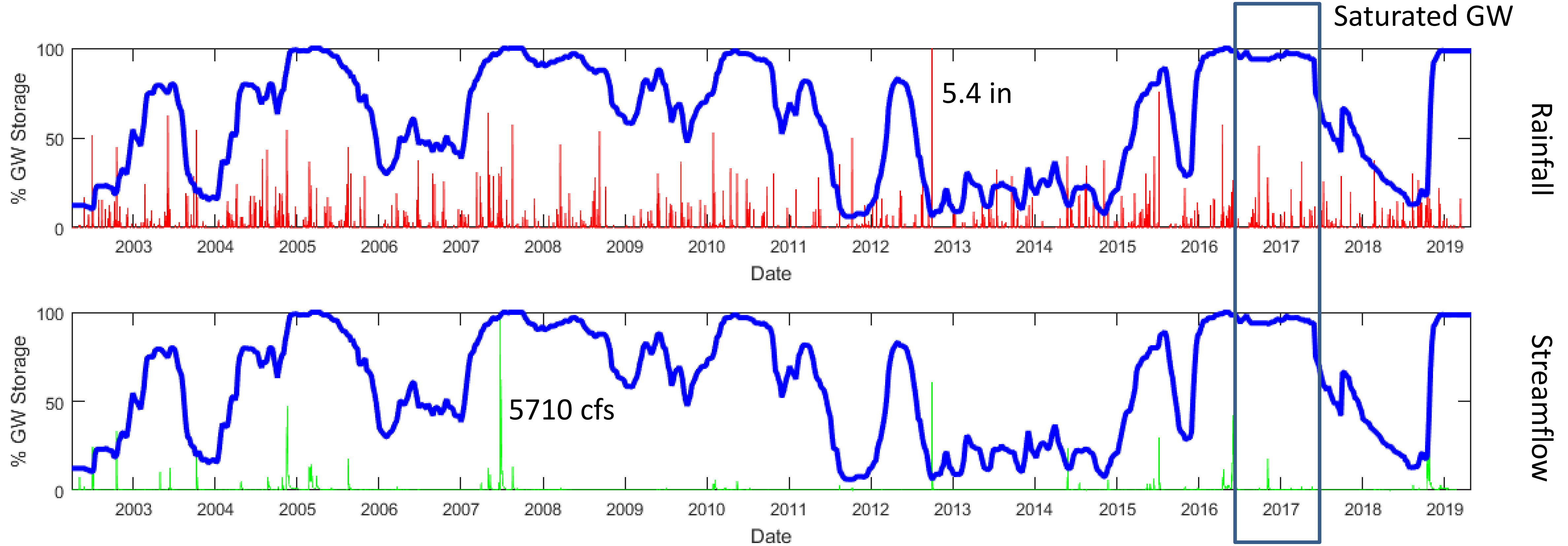
Soil Moisture Data Analysis – GRACE Data



GRACE Data - % of Groundwater Storage @ Ballinger, TX
Rainfall recorded @ Ballinger, TX

Task #6 – Soil Moisture Data Analysis – GRACE Data

Decent Rain
Saturated GW

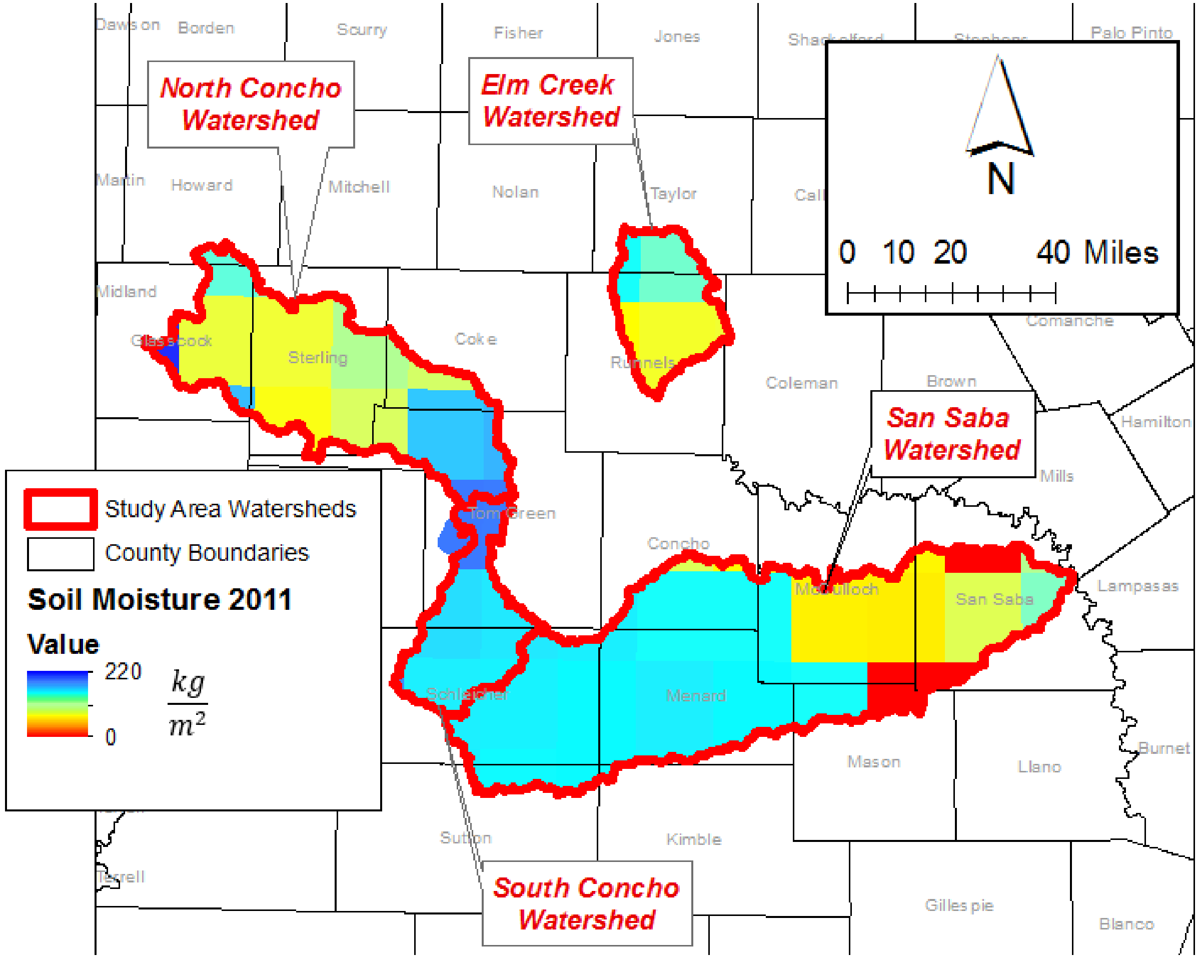


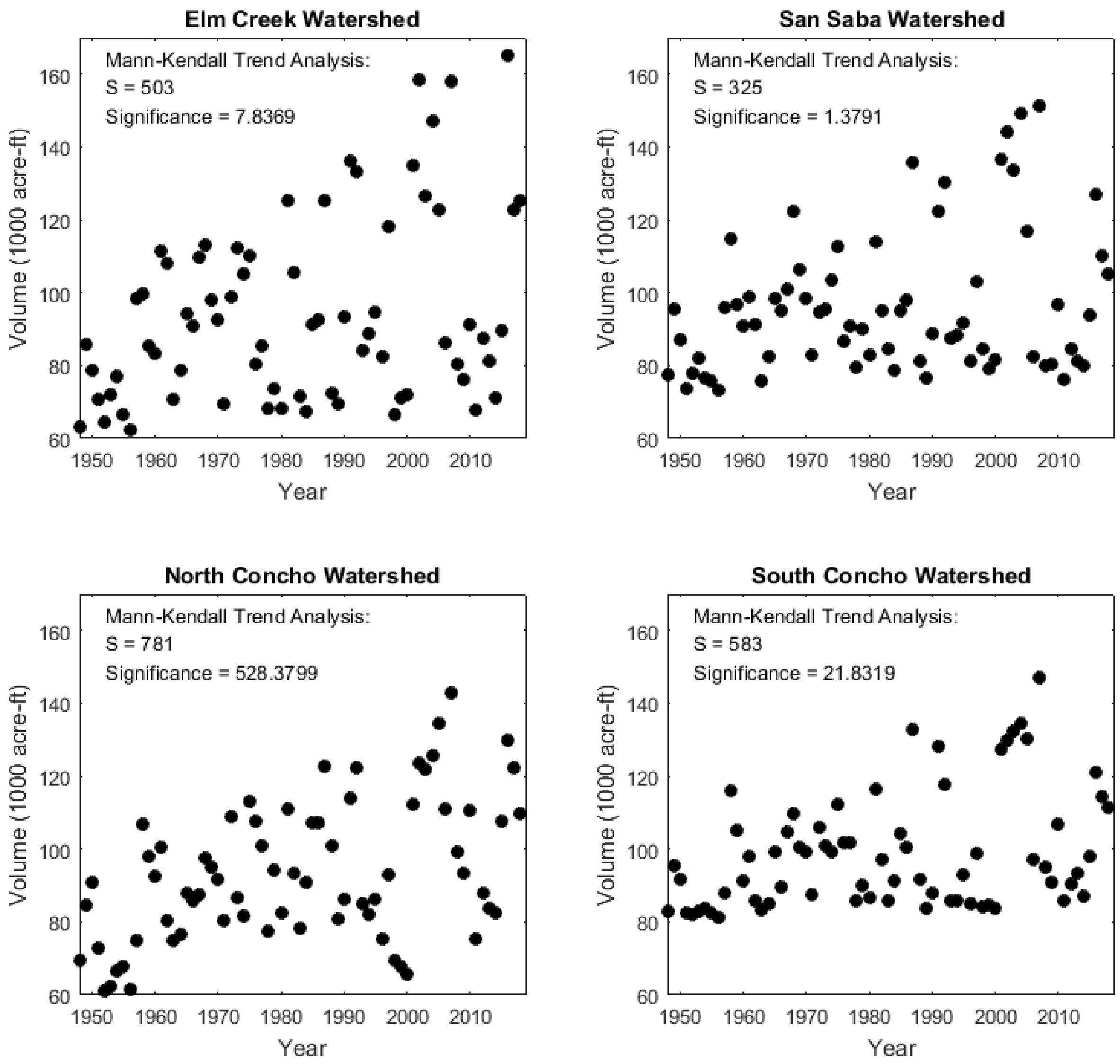
Decent rain events
When soil was saturated:
Large Runoff

Large Rain Event when soil was dry:
Large runoff & No soil recharge

Minimal Streamflow
Response

Task #6 – Soil Moisture Data Analysis – NLDAS

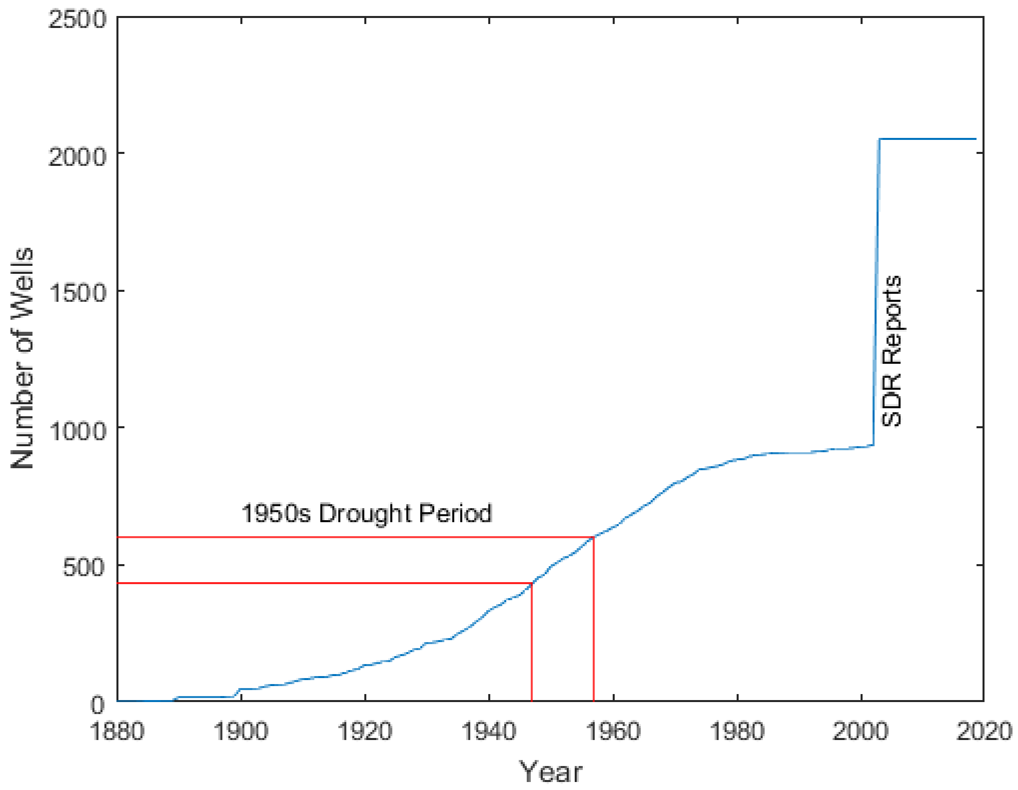


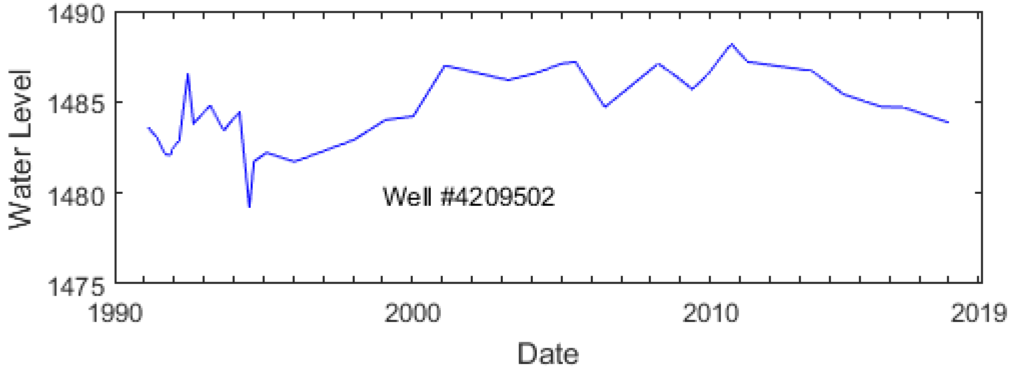


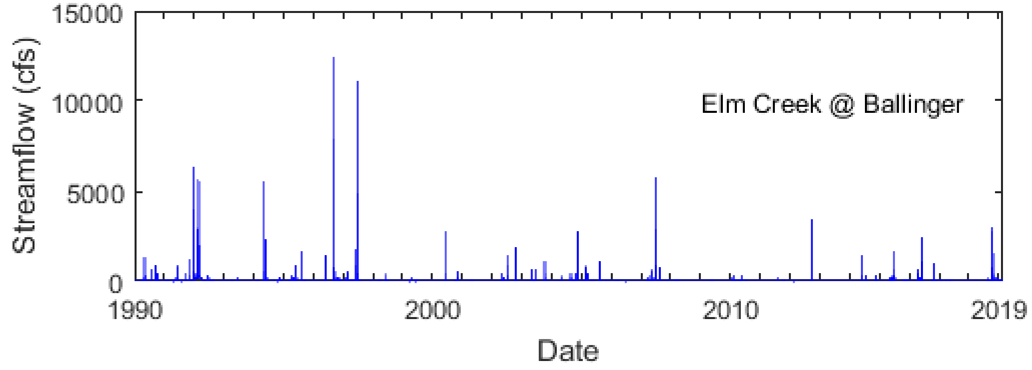
Increase tied to Increasing Rainfall frequency w/ lower intensity?

Task #7 – Groundwater Level Evaluations

Looked at TWDB GW Database, SDR Database
Identified shallow wells within 1-mile of major study-area streams
Plotted # of Wells vs. Year (assuming SDR wells are post 2003)







Well = 0.7 miles from creek, 34 ft deep
Stable water levels over 30 years

Task 8 – Demonstrating Cause and Effect – RRR

Upper Colorado Water Balance Model (UCWBM)

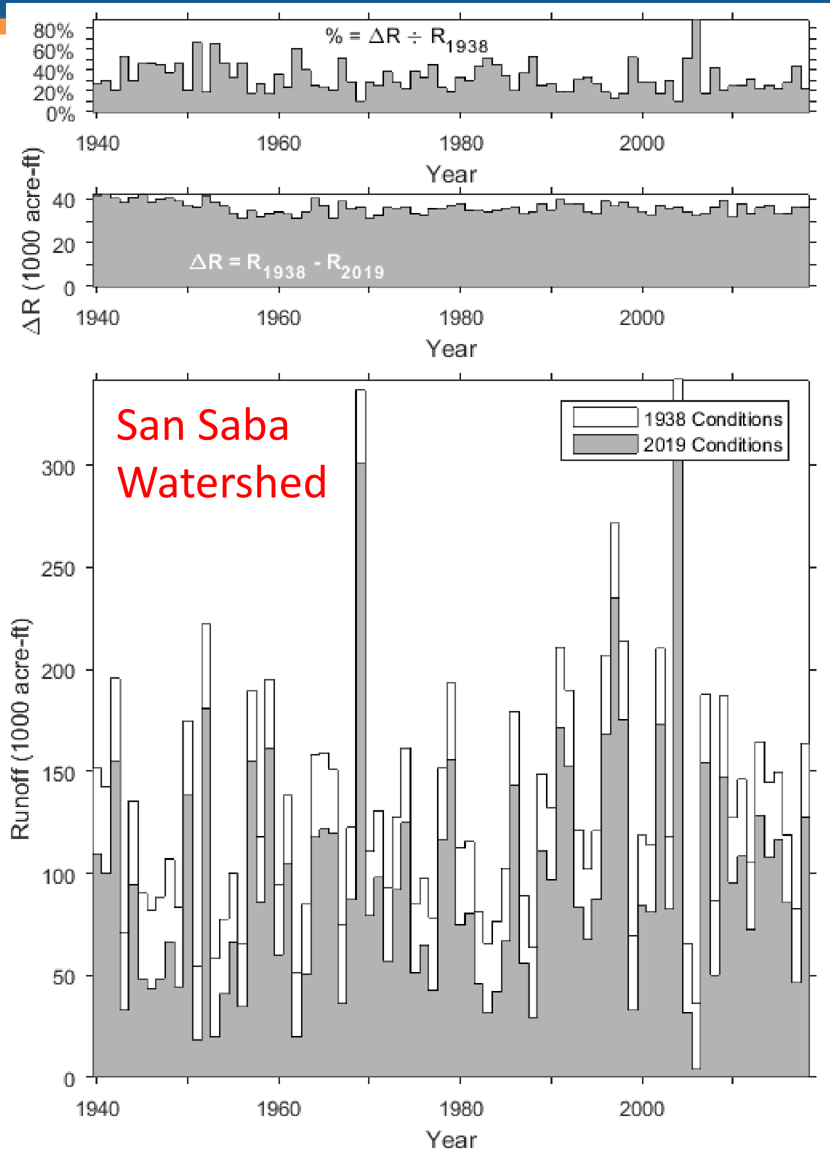
$$q = \frac{(P - I_a)^2}{(P - I_a) + S}$$

Uses Measured daily Rainfall
Applies SCS Curve Number Method to compute Q
Incorporates land use/land cover change
Accounts for small ponds:

- Storage prior to discharge downstream
- Evaporation loss from ponds

$$I_a = 0.2S$$

$$S = \frac{1000}{CN} - 10$$



<u>Designed for comparing modeled Q – not for matching measured Q</u>

DRAFT REPORT – Submitted to TWDB July 12
Comments due back to me: August 12
Final Report Due: August 31, 2019

Evaluation of Rainfall-Runoff Trends in the Upper Colorado River Basin Phase II

Presentation to BBASC

August 2, 2019

QUESTIONS/DISCUSSION

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